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16. Abstract

Experiments were performed to determine whether the various characteristics of the visual process are reflected in fixation optokinetic nystagmus (FOKN). Subjects were to solve various classical visual perspective problems while their FOKN were recorded. Investigations showed that FOKN is one of the subtlest indicators of the tonic system of the eyes.

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STUDY OF THE CHARACTERISTICS OF THE VISUAL PERSPECTIVE PROCESS BY THE FOKN METHOD

V. Ya. Romanov

A tendency is noted in modern psychological literature to relate visual attention with the phenomenon of variability in perceptive organization, i.e., with changes in the subjective images of stationary external objects (Kohler, Adams, 1958; Krech, Crutchfield, 1969, and others). Clear examples of such phenomena are the reversal of ambiguous figures, the alternating figure-ground relation (Rubin, 1921; Koffka, 1935, Osgood, 1953), the reorganization of the elements of visual objects (Schumann, 1904; Woodworth, Schlosberg, 1954; Kohler, Adams, 1958), the discrimination of disguised figures (Gottschaldt, 1926; Woodworth, Schlossberg, 1954, and others), the occurrence of nonsensory figures (Gibson, Crooks, 1938; Hebb, 1949), etc. /42*

In the case of the perception of ambiguous figures — for example, Necker's Cube — a constant alternation of the perspectives of the cube is observed. The alternating figure-ground relation can take place as dramatically and suddenly without any external reasons. The reorganization of visual objects is very distinctly observed in special objects of the Shumann's chessboard type (1904), which represents a set of black squares; when gazed at persistently, they

*Numbers in the margin indicate pagination in the original foreign text.

represent either horizontal rows or vertical rows, or large squares, or else a cross, etc. Classical examples of disguised figures are Gottschaldt's figures (1926). They demonstrate in particular the internal stress or effort in the attempt to discriminate a simple figure written inside a complex configuration. The concept of the nonsensory figure was introduced by D. Hebb in 1949, and it describes the phenomenon of active recognition of objects or figures in a uni- /43 form, sensorially unformed environment. As an example of such an occurrence, D. Hebb presents a gardener seeing the site where it is suggested to lay flower beds on an even grass plot.

The main feature common to all the described effects is the absence of a rigid, unambiguous connection between external influences and the perceptive results. It is important for us to note that similar fluctuations, reorganizations, active discrimination of figures, as well as other events of additional "degrees of freedom" of the image in relation to the external stimulus were related to attention by many authors, and were described as its "play", "caprice", "adjustment", etc. (Shumann, 1904; Hebb, 1949; Osgood, 1953; Kohler, Adams, 1958; Vernon, 1964, 1969; Hochberg, 1970, and others).

The described phenomena reveal a variable degree of randomness or nonrandomness (automaticity), complexity, intensity, etc., of the visual perceptive process.

Let us dwell on some of these characteristics of the perceptive processes in more detail.

As is known, the random nature of any act is determined by the problem. The organizing factor of the random setup in perception was investigated by many authors. Thus, as early as the first experiments of O. Kulpe (1904), it was shown that the content of perception of tachistoscopically appearing objects depends entirely on the instruction to give a report on certain aspects of the stimulation. Analogous phenomena were the subject of discussion and investigation by a series of more recent authors (Gibson, 1941; Hebb, 1959; Fraisse, 1961, and others). The nonrandom features of perception are revealed, for example, in the working out of visual automatisms, which insure the instantaneous evaluation, analysis, and even interpretation of a situation — "unconscious mental conclusions" of G. Helmholtz (1963); "perceptive categorization" of J. Bruner (1957), etc. The random and nonrandom aspects of perceptive activity are characterized by complex dynamic relationships. The observer can intervene in the operation of nonrandom mechanisms; however, the latter often takes the upper hand. Thus, in the experiments of L. Penton, S. Solley, and S. Brandt (1969), the subjects succeeded in increasing the frequency of the ambiguous figure reversal during the instruction (reverse the figure as fast as you can", and maintain the perception of one of the variants of the figure if the opposite instruction was given, "keep one image as long as possible". However, in the final analysis, the reversal took place in spite of the random counteraction.

A similar but distinctive feature of visual activity is the /44
degree of their complexity or intensity.

The Gestalt psychologists, who studied the principles of perceptive organization, were the first to distinguish between peripheral (sensorial, disconnecting) and central (perceptive, organizing) forces. In their numerous experiments, they showed that perceptive organization can be hindered, either by weakening of the "peripheral" forces acting in the same direction as the "central" forces (for example, the decrease in the contrast of contours, introduction of discontinuities in the figures, etc.), or by the action of peripheral forces acting against perceptive organization (all kinds of methods of noise interference, disguising of figures, etc.; Kohler, 1929, Koffka, 1935; Wertheimer, 1938).

At the present time, the central and peripheral forces of Gestalt psychologists sound to us no more than a metaphor; however, the description of processes with passive and active course, as well as the experimental methods which facilitate or hinder the perceptive work, maintain their value also today. The visual activity becomes more intense if its peripheral conditions are poor or conflictual. Examples are, on one hand, various kinds of threshold problems, detecting signals of low intensity, discrimination between similar stimuli, recognition of objects presented for a short time, etc., and on the other hand, the above-described problems of the active discrimination of the disguised figure, of figures situated in an ambiguous or undefined object, in a homogeneous environment, etc.

Another important feature of the visual process can be distinguished — the dimensions of the field where it is accomplished. The problem of the simultaneous perception field has been raised for a long time in experimental psychology, and is known under various names. It is this problem which investigators have in mind when they speak about the functional potential of peripheral vision, the volume of perception, the operational field of vision, etc. (Woodworth, Schlosberg, 1954; Sanders, 1963; Gippenreyter, 1964; Moray, 1970, and others).

The enumerated features of the visual process coincide with the often-described features of visual attention, its randomness, its degree of intensity or concentration, the area of simultaneous adjustment, etc.

All the above refers to the typical form of the visual process which takes place in the presence of an external object.

However, another no less important form of visual activity exists, which takes place in an internal plane, in the absence of an external object. The internal images or visual representations literally permeate all forms of psychic activity. For example, the general programming the oncoming battle must be able to consider /45
mentally all the spatial relationships, all the combinations of objects, "to see" their disposition on some imaginary map, diagram, plan, etc. (Teplov, 1961). In solving a chess problem, the image of the chess board with the disposition of the individual parts is represented in each move "as images in an internal mirror; without this condition they (the chess players) would not be able to foresee

the consequences of their moves and of their opponent's moves" (Binet, 1889). The list of such examples can easily be made much longer.

Usually, the involvement of vision in other kinds of activity is called visualization (Zinchenko, 1971, Arnheim, 1972, and others). Mention is also made of nonvisual types of thinking, mnemonic, and other processes. Several authors emphasize, on the contrary, the potential independence of the described forms of visual activity, calling it internal vision (Binet, 1889; Kandinskiy, 1952).

As with regard to "external vision", one can speak about the degree of randomness or intensity of the internal visual process, the magnitude or dimension of the field taken in by the internal gaze.

A clear example of the extreme nonrandomness of internal vision is given by the cases of visual pseudohallucinations. One of their main features is their spontaneous, automatic, and intrusive character (Kandinskiy, 1952).

On the other hand, how hard it is at time for any of us to imagine even a well-known face and to "keep" it in sight internally.

Intermediate cases have also been described. For example, certain faces have the ability of randomly inducing very clear visual images, which are kept for a long time and then switched off arbitrarily. One distinctive case was described by A. R. Luriya (1968). His patient could very easily recall extremely detailed visual images of objects, situations, and events which had taken place many years ago. Finally, by means of the internal vision, we can represent to ourselves not only individual small figures, but also whole complex pictures which occupy the entire internal visual field. This assumes in pathology the form of "panoramic hallucinations" (Kandinskiy, 1952).

The purpose of the present work has been to discover whether the various characteristics of the visual process are reflected in the properties of the fixation optokinetic nystagmus (FOKN).

The FOKN was investigated by us in previous works (Gippenreyter and Romanov, 1968, 1970). It appeared that this type of eye micro-movement depends on the directional effect of the subject's activity: a suppression of FOKN activity takes place during visual problems, while its surging is observed in the solving of nonvisual problems (auditory, tactile, mental). In the present work, only visual problems were used. In such a manner, not the modality of the activity, but instead the subtle features of the internal visual modalities have been observed. /46

Method

The classical objects of perceptive organization were used in the experiment: Necker's cube, Gottschaldt's figures, Shumann's chessboard, and noise squares. Simple colored squares of different areas were also used (see Figure 1).

The dimensions of Necker's cube, Gottschaldt's figures, and Shumann's chessboard were always constant, with a side of 4°. The sides of the colored squares were 50', 4° and 8°. The noise squares represented squares drawn one inside another, with sides ranging from 50' to 5°.

Several problems were given to the subjects with regard to the above-named objects. These were organized in series, according to the investigated parameters of the visual process.

First series. The problems of this series comprised comparing the conditions of random maintenance of perceptive organization and passive observation.

Necker's cube was used (Figure 1a) as the object. Two different instructions were given to the subject: 1) keep one position of Necker's cube in a random manner; 2) observe the cube passively.

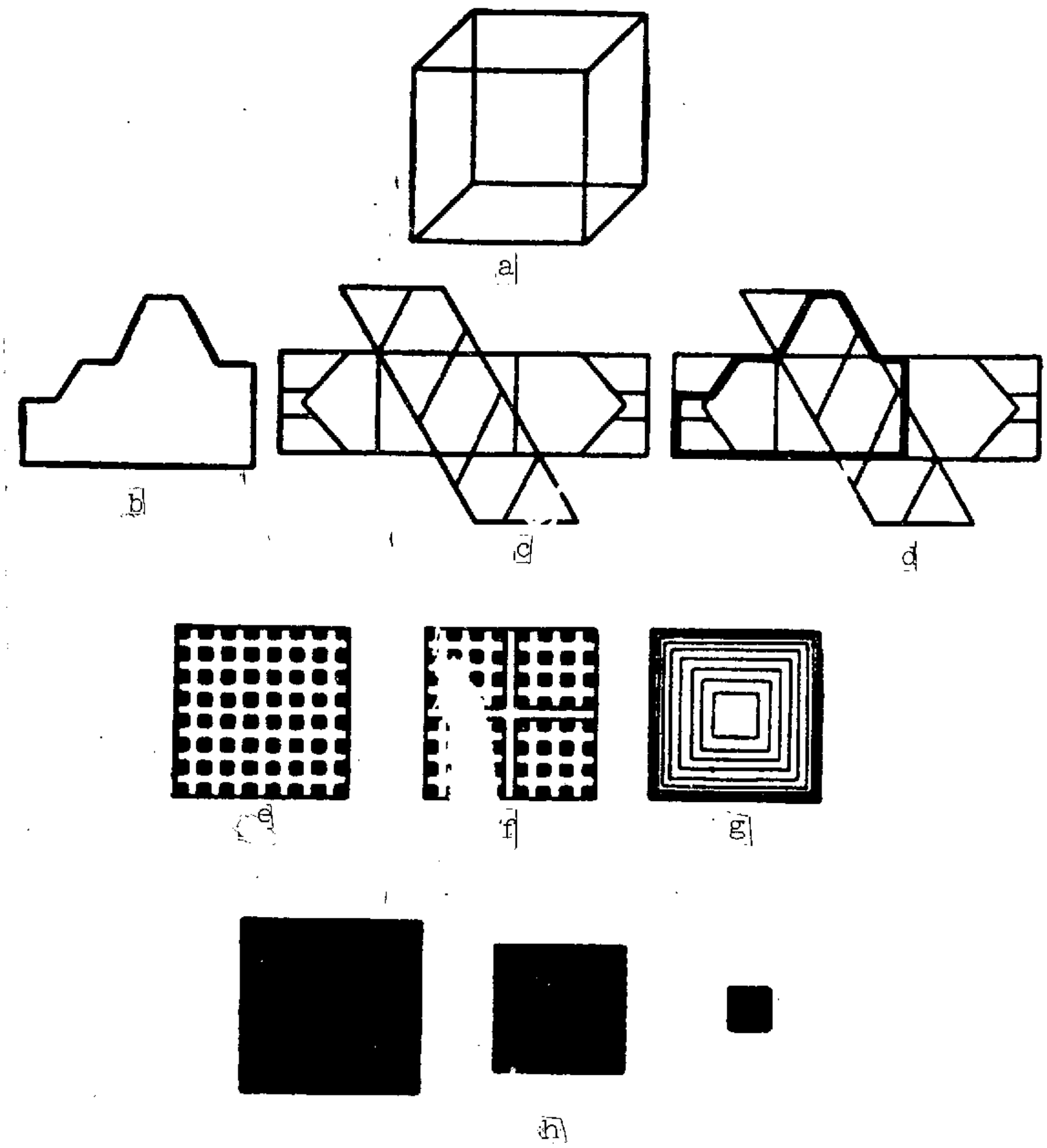

Figure 1. Stationary objects used in visual problems:

a — Necker's cube; b — Gottschaldt's figures; c — disguised figure of Gottschaldt; d — undisguised figure of Gottschaldt; e — Shumann's chessboard; f — sensory figure on Schumann's chessboard; g — noise squares; h — colored squares

Second series. Here the problems of perceptive organization under difficult and easy conditions were compared. The following conditions and objects were used:

1. Gottschaldt's figures:

a — discriminate the disguised figure (Figure 1c);
b — perceive the undisguised figure (Figure 1d).

2. Shumann's board:

a — discriminate the nonsensory figure in the shape of a cross (Figure 1e);
b — observe the graphically discriminated (sensory) figure in the shape of a cross (Figure 1f).

3. Noise squares:

a — discriminate the peripheral noise square (Figure 1g);
b — watch the central noise square (Figure 1g).

Evidently, all the problems under the heading (a) are difficult /47
conditions, while all the problems under the heading (b) are easy conditions.

<u>Third series</u>. The problems compared here assume a variable magnitude of the area of adjustment of the visual attention.

Red squares were used (Figure 1h). The subject was instructed to "take in" or "concentrate" on the surface of squares with different dimensions: 50'; 4°; 8°.

<u>Fourth series</u>. In the first series, tests were performed with /48
the purpose of elucidating the reactivity of FOKN to certain aspects of the activity of internal vision:

1. Type of thinking, whether visual or nonvisual. The problem of the "colored cube" was used, in which the visual and logical types of thinking (Walter, 1966) were revealed. The subject was instructed: "Imagine a toy cube. It is colored. Now imagine that you would cut it into two halves, then you would mentally cut each half again into

two halves, into rectangular pieces, and you would repeat this operation the third time. Now imagine to yourself the small cubes which you obtained in this way. How many cubes are not colored?"

2. The efficiency of the random effort to call up a visual representation. The subject was preliminarily given an object — noise square; then the square was taken away and the subject was asked to "imagine it again on the screen".

3. Adjustment of the internal vision to objects with different areas. The same noise squares were represented; the subjects were supposed to adjust alternatively to the area of the central, medium, and the outermost squares (in this way the noise factor was removed).

The experiments were performed with the same setup as the experiments described in the article by Yu. B. Gippenreyter and V. Ya. Romanov (1970): the subject was placed in front of a semi-transparent mirror, through which he could see a screen on which a stationary object was projected. A second screen was reflected in the mirror on which vertical black and white stripes were moving.

The physical properties of the moving stripes were kept unchanged in all the series: speed 8 deg/sec; 5 black and 5 white stripes were in the field of vision at the same time, while the angular dimension of each stripe (black or white) was 4°. The stripes always moved to the side which coincided with the asymmetry of FN in the given subject. The experiments were accompanied by recordings of the eye movements, using the photo-optical technique. The horizontal component of the eye movements was recorded in the experiments. In all, 8 subjects participated in the experiments; no less than 3 subjects took part in each series; and about 6 experiments were performed with each subject for every problem.

Results and Discussion

In all the experiments of these studies, the "typical visual FOKN" was observed in all the subjects (Gippenreyter and Romanov, 1970). Against the background of a general picture of FOKN, the variants of the visual conditions and problems utilized in these experiments gave additional regular changes of the FOKN.

1. The main result obtained during the introduction of the factor of randomness (first series), consisted in the lengthening of /49 the slow phases and the increase of their amplitude. This can be seen from the recordings of FOKN in Figure 2, as well as from the mean cycles* (Figure 2).

2. The main result in the hindered visual process, in distinguishing the disguised figure of Gottschaldt (second series), consisted in a considerable lengthening of the slow phases of FOKN (Figure 3).

The opposite result was obtained in trying to discriminate the nonsensory figure on Shumann's board: the length of the slow stages decreased, as did their amplitude. Samples of individual tracings of FOKN and of its mean cycles for the given problem are presented in Figure 4. In their report, the subjects noted that this problem was extremely difficult. They reported that they had attempted to find "external props" in order to see and retain the figures; however, they rarely succeeded in doing so. The perception of the sensory figures always went, in their words, easily and simply, while the gaze was fixed most frequently on the center of the object. One of the most conscientious subjects (S. I.) solved the problem by shifting his gaze to the left and to the right of the chessboard center. The subject, in his own words, "divided with his gaze the

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*The mean cycles of FOKN were constructed on the basis of the mean values of time (t), amplitude (l), and speed of the FOKN drift (their derivative) ($V_{av} = l_{av}/t_{av}$) for each subject who solved a given problem. These values are entered above the triangles which are a graphic representation of the mean cycles.

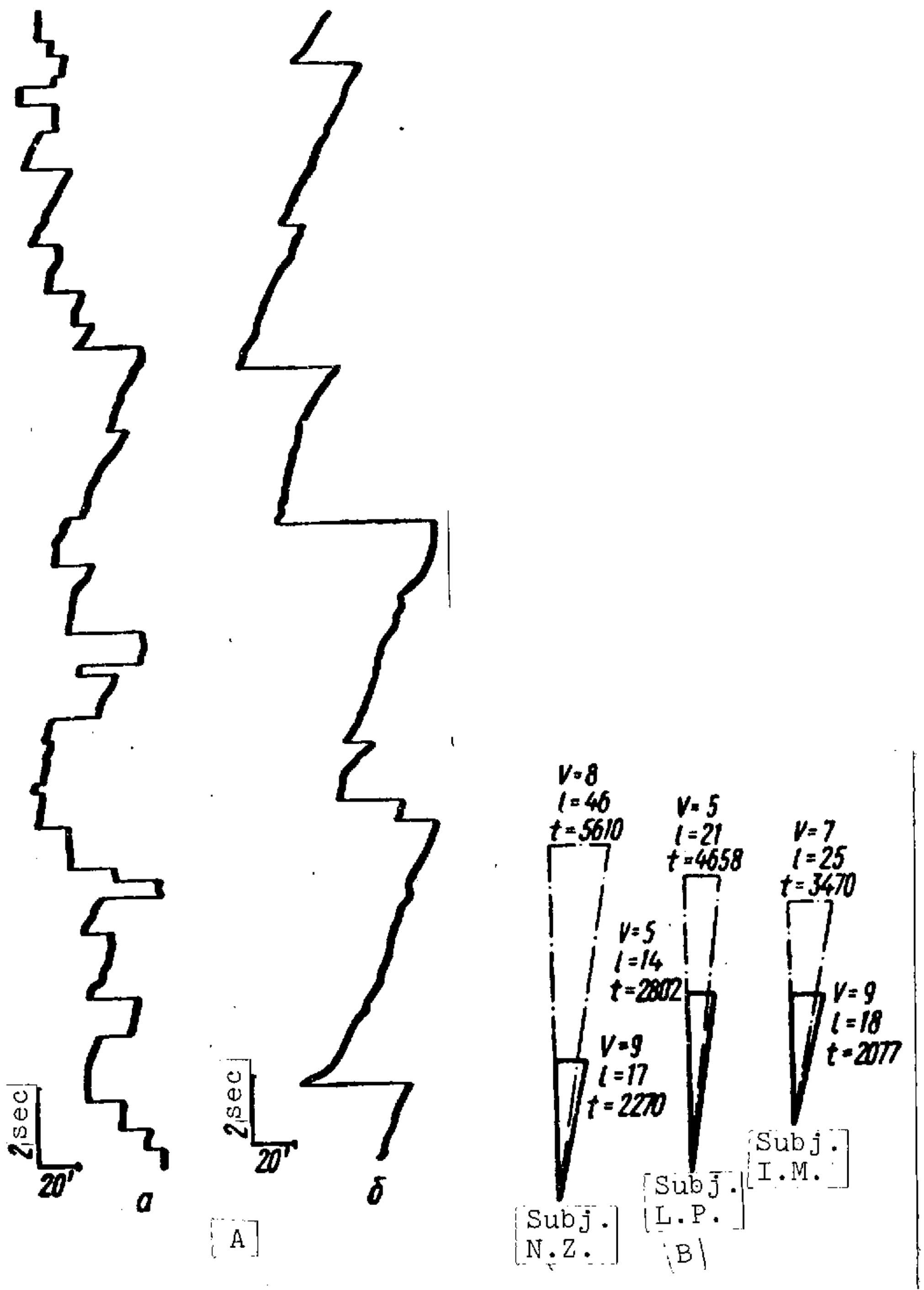
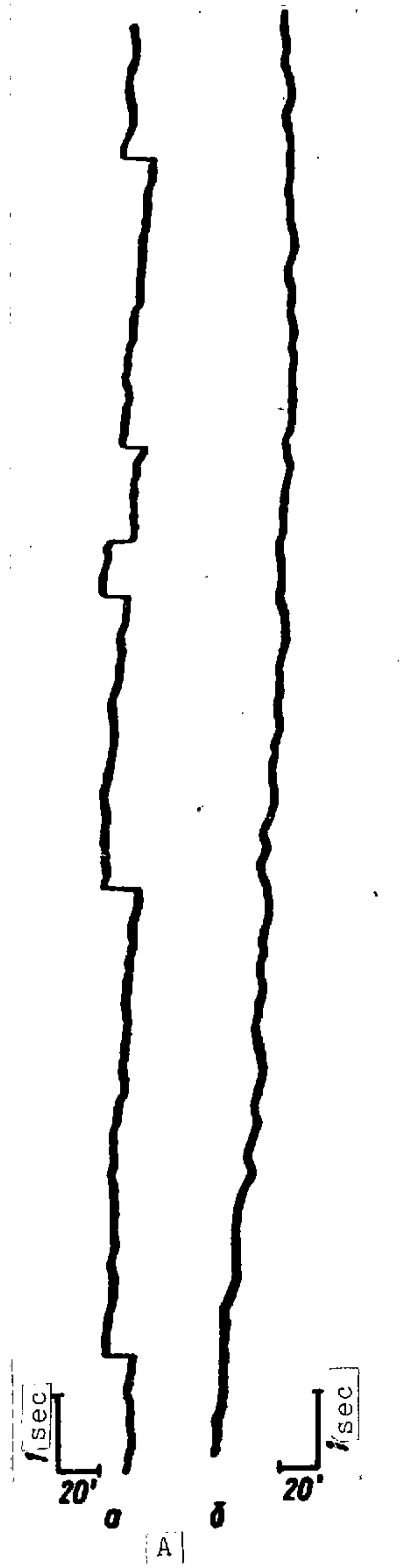


Figure 2. FOKN in the work with Necker's cube:

A — FOKN recordings (subject L.P.): a — passive perception of cube's position; b — active regaining of each position of the cube; B — Mean FOKN cycles in three different subjects: continuous line — passive retention; interrupted line — active retaining (the time course is in all the recordings of this article from below upward)



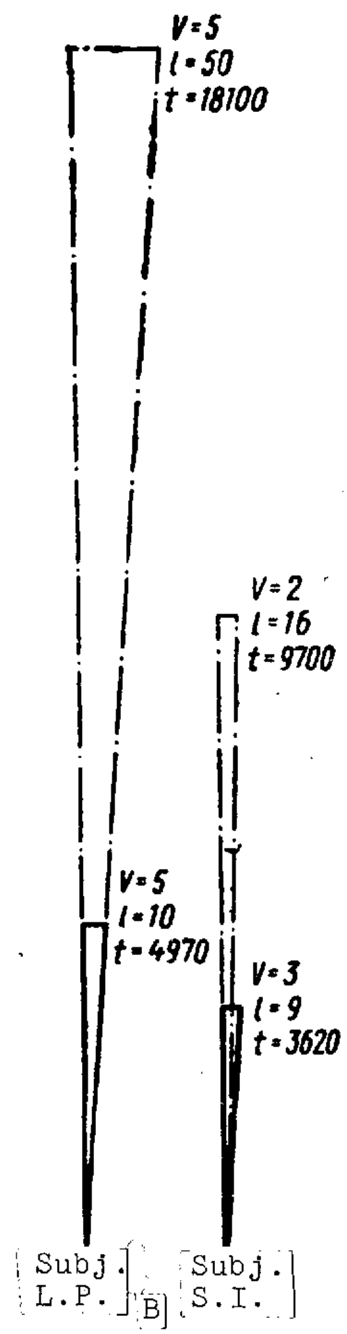


Figure 3. FOKN in the experiments with Gottschaldt's figure:

A — FOKN recordings (subject L.P.):
a — perception of undisguised figure;
b — discrimination of disguised figure;
B — mean FOKN cycles in two different subjects: continuous line — perception of undisguised figure; interrupted line line — discrimination of disguised figure

center of the figure so as to obtain a cross, and in such a manner distinguished four squares".

3. The result obtained during variation of the area of adjustment of the attention (third series) consisted in a regular increase in the amplitude of the slow phases of FOKN with the increase in the area of adjustment of the squares. The indicated regularity is graphically presented in Figure 5.

4. Two factors, which had been changed independently in previous experiments, were combined in special tests: the complexity of the visual process and the area, in relation to which the process took place. For this purpose, noise squares were presented (Figure 1f), with the instruction to distinguish the third square from the edge (with a side of 3.7°). This problem was compared with the perception of the non-noise square with a side of 50'. It should be mentioned that all the subjects experienced great difficulty in distinguishing the noise square. Despite their attempts, they never succeeded in seeing clearly the boundaries of the square; in this situation, they attempted to distribute their glance over an area which approximately corresponded to its dimensions.

Figure 6 depicts samples of recordings and mean cycles of the FOKN for the given tests. It can be seen from the recordings that in the case of the discrimination of the large noise square, both the amplitude (effect of the larger area) and the duration (effect of the difficulty) of the slow phases of FOKN were increased. The comparative results according to the conditions: /50

— small easy square,
— large easy square,
— large difficult square,

are presented in the mean cycles of FOKN in the same figure.

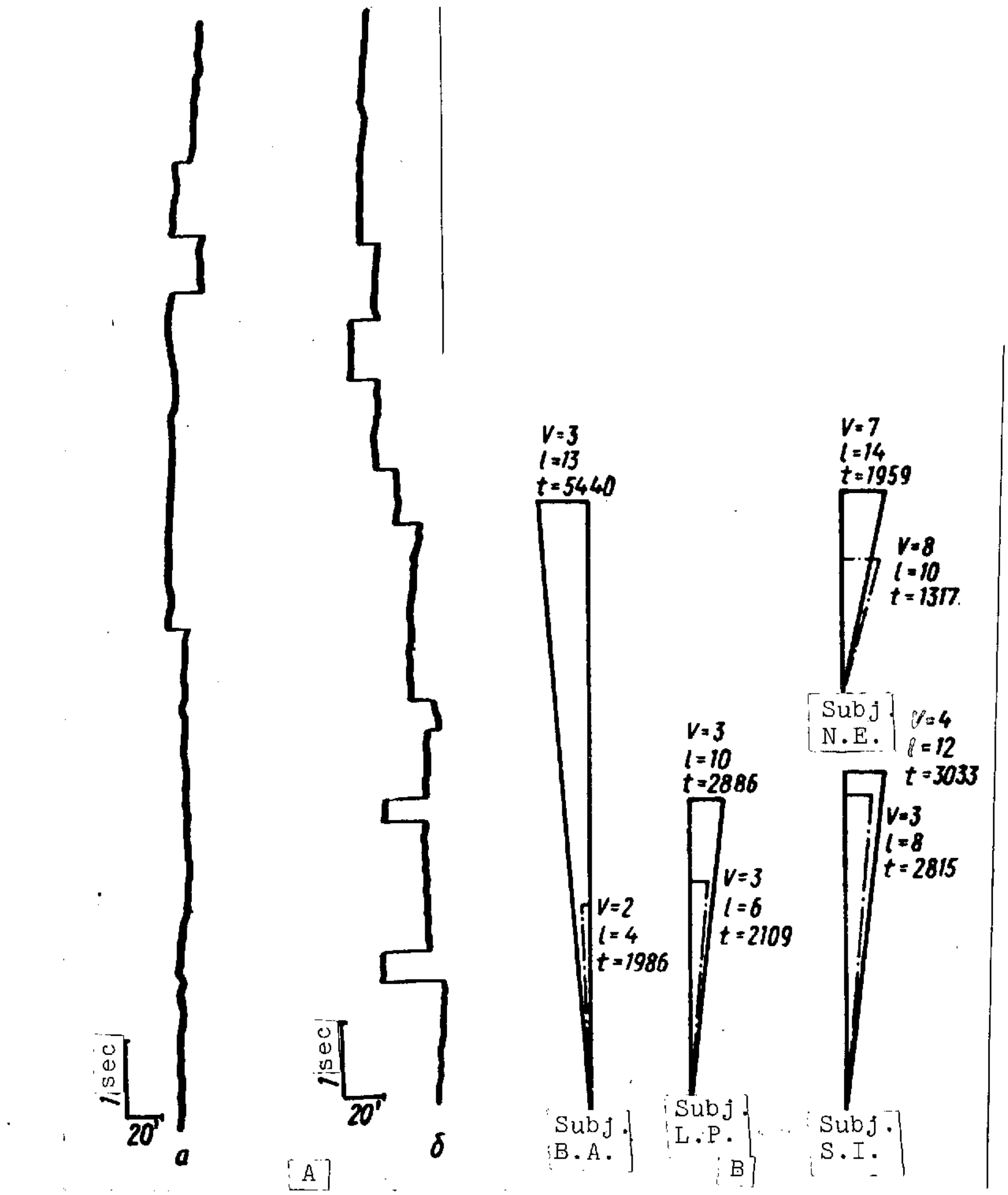
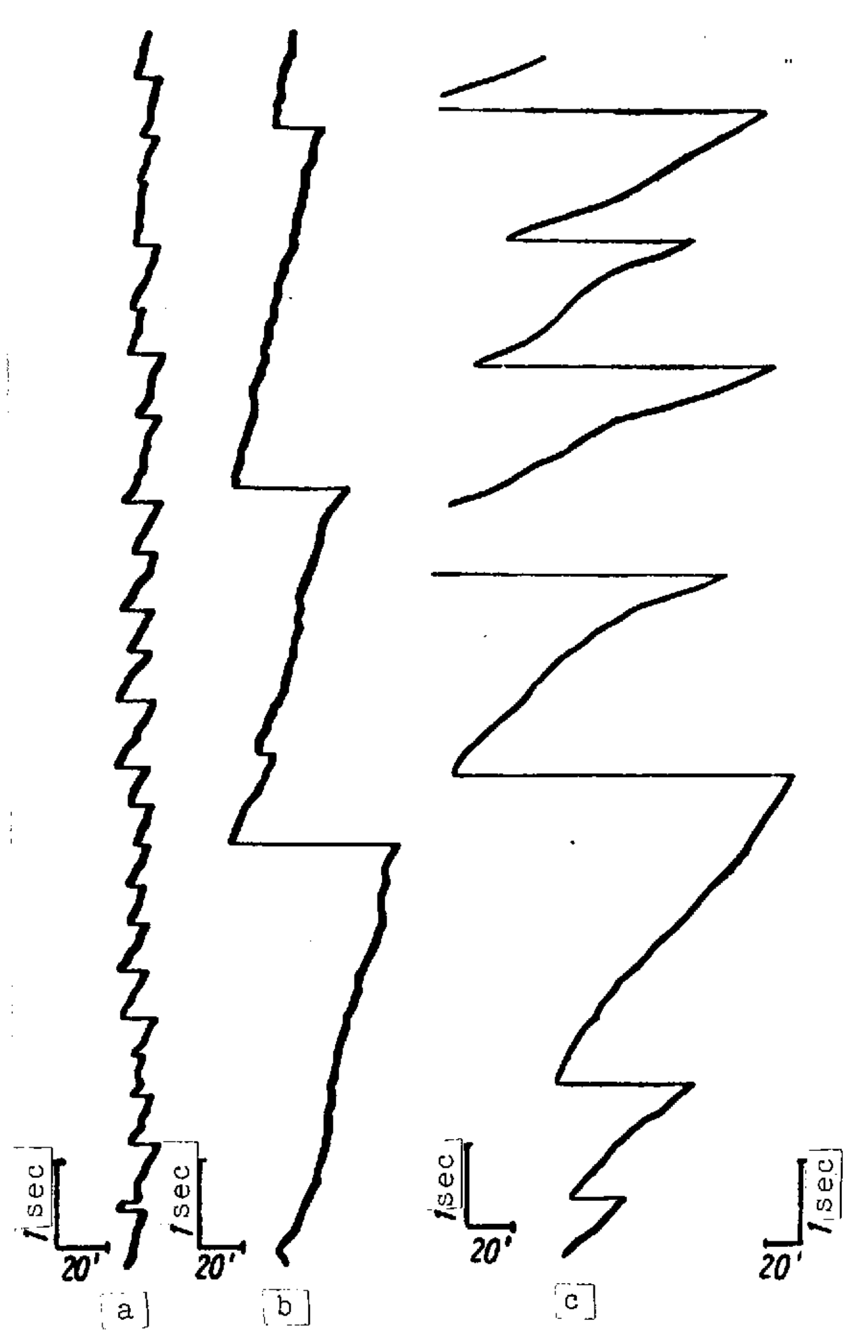


Figure 4. FOKN in the experiment with Shumann's chessboard:

A — FOKN recordings (subject L.P.): a — sensory figure perception; b — nonsensory figure discrimination; B — mean FOKN cycles in four different subjects: continuous line — sensory figure perception; interrupted line — discrimination of nonsensory figure



A

Figure 5. FOKN during adjustment of the attention to squares of different areas:

A — FOKN recordings (subject N.E.): a — 50' square; b — 4° square; c — 8° square. The interruptions in the recordings c are due to the fact that the light beam went beyond the limit of the screen of the recording instrument

(Figure continued on following page)

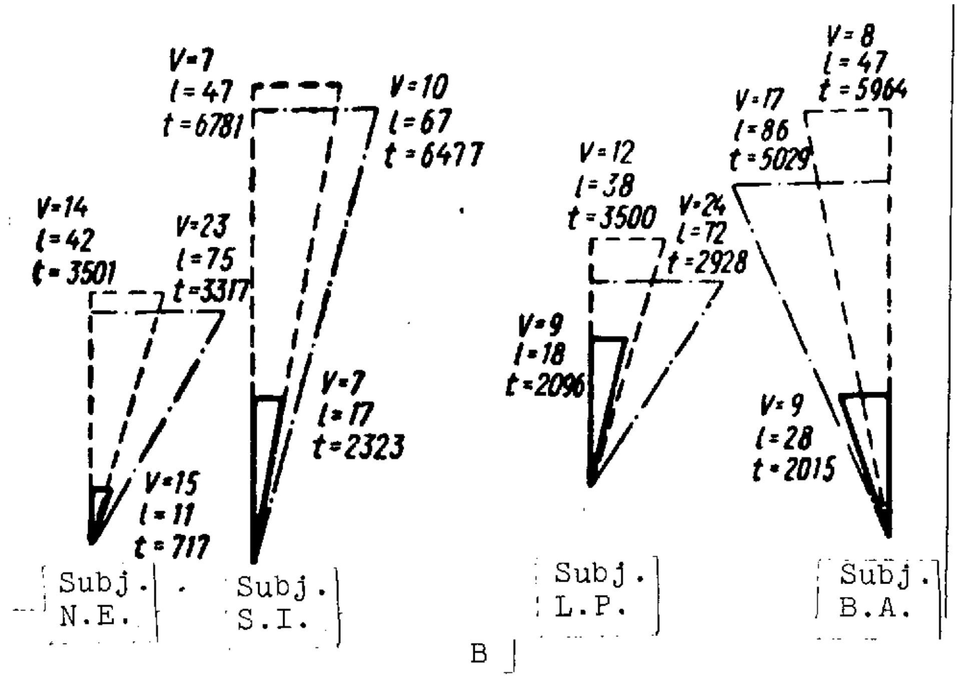


Figure 5. (continued):

B — Mean FOKN cycles in four different subjects: continuous line — 50' square; dotted line — 4° square; interrupted line — 8° square

With almost all the subjects, there were moments during the discrimination and the attempt to retain the noise square when they passed from a stage of efficient discrimination (although not always
rigorous) either to simple fixation of the upper or lower angle of /52
the square, or to alternating fixation of its side. The recordings taken during this time always revealed marked decreases in the length and amplitude of FOKN. The latter started to coincide in its nature with the FOKN observed during the problem of fixation of a large dot. In the course of the experiment, the experimenter could observe visually the characteristics of the FOKN (by the movement of the light beam). In all cases when the experimenter observed an increase in the frequency of FOKN, he received a positive answer when asking
the subject whether he lost the integral perception of the square. /53
According to the report of the subjects obtained during or immediately after the experiment, those parts of the recordings (sometimes these were recordings of the entire experiment), which corresponded to the period of failure to solve the problem were selected. Samples of such parts of FOKN recordings in various period of unsolved problems

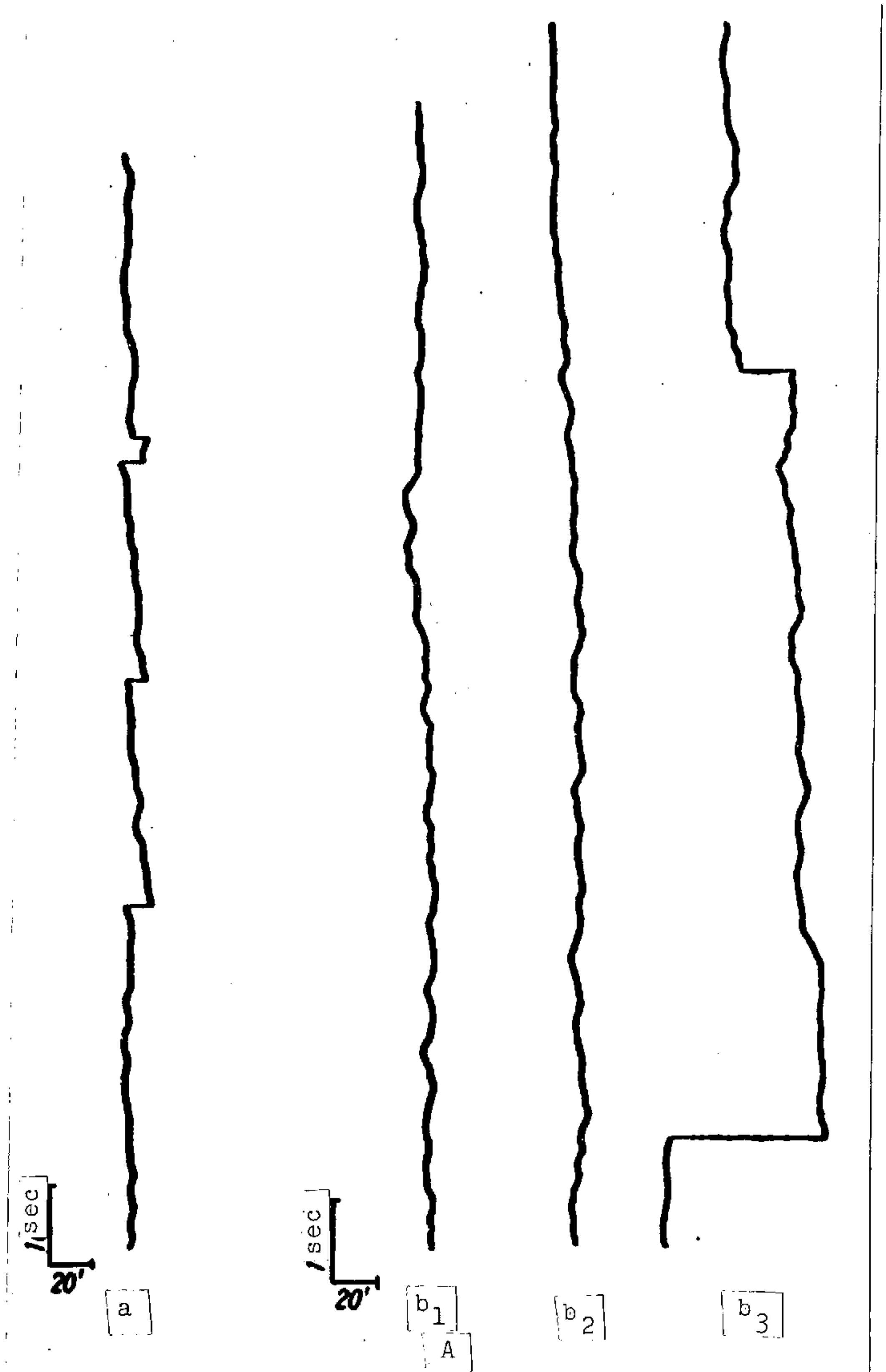


Figure 6. FOKN in the experiment with noise squares:
(Figure and caption continued on following page)

are presented in Figure 7. In the same figure, the results of the statistical processing of FOKN are given in the form of the mean cycles of the latter, as compared to the parts corresponding to successful solving of the problem.

5. Samples of recordings of the FOKN and of their statistical processing during the solving of the problem mental "sawing" of the cube, and determination of the number of unpainted sides (fourth series), are presented in Figure 8.

Analysis of the data shows that under conditions of the described problem, two types of changes occur in the FOKN, a "visual type", i.e., a considerable increase in the duration of fixation, and a "mental type", an increase in the amplitude and speed of the drift, and a decrease of their duration. It appeared that the indicated types correspond to the methods used by the subject to solve the problems, as reported by

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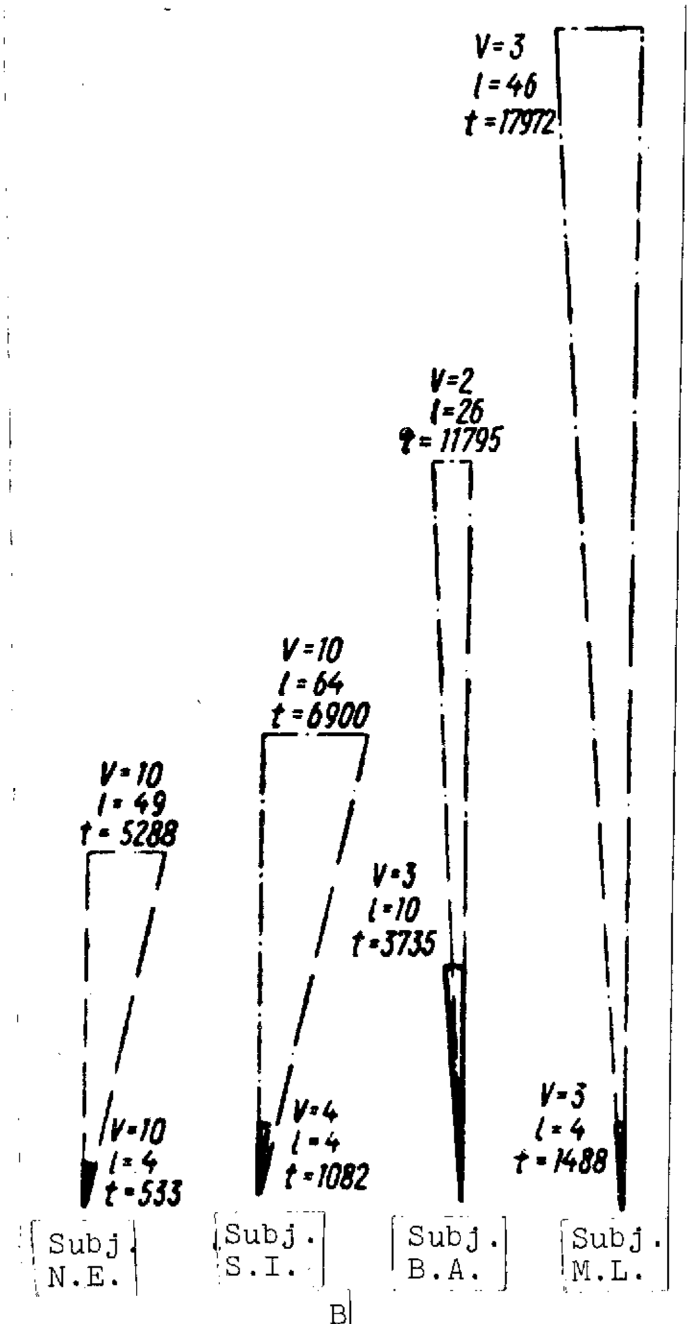

Figure 6. (continued):

A — FOKN recordings: a — perception of the non-noise 50' square; b_1 - b_3 — discrimination of 3.7° noise square (b_2 and b_3 are a continuation of b_1); B — mean FOKN cycles in 4 different subjects:(continuous line — perception of 50' non-noise square; interrupted line — discrimination of 4° noise square; dotted line — perception of the 4° non-noise square

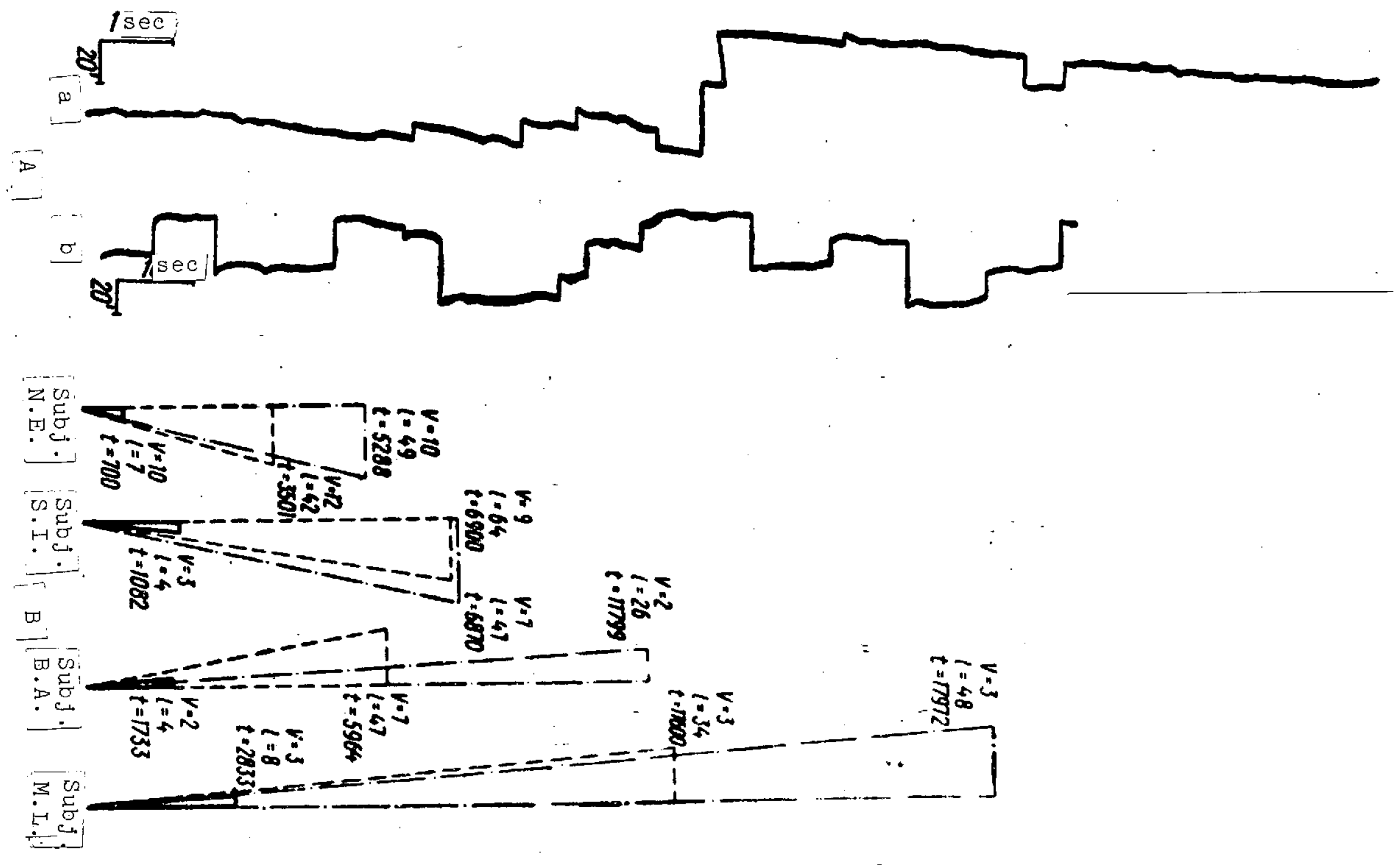

Figure 7. FOKN in discrimination of the noise square during the period of failure:

A — FOKN recordings: a — fixation of lower and, subsequently, upper angle (subject L.P.); b — alternating fixation of the sides (subject B.A.); B — mean FOKN cycles in 4 different subjects: continuous line — failure; interrupted line — solution of the problem

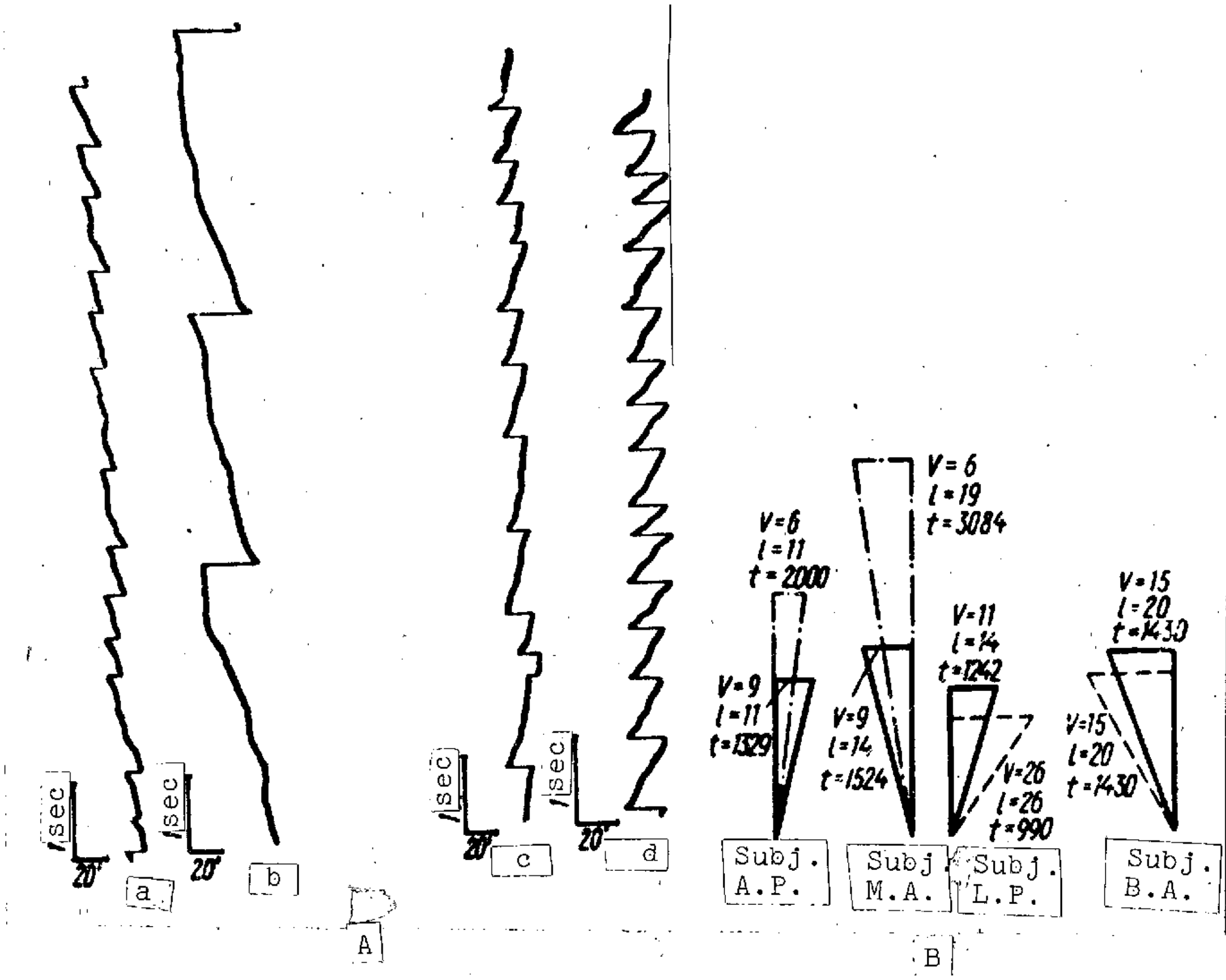

Figure 8. FOKN during solution of the problem "small cube": A — FOKN recordings: a — background FOKN (subject M.L.); b — visual FOKN during the solution of the problem (subject M.L.); C — background FOKN (subject L.P.); d — mental FOKN during solution of the problem (subject L.P.); B — mean FOKN cycles in four different subjects: continuous line — background FOKN; interrupted line — visual FOKN; dotted line — mental FOKN

them. The first type was shown by subjects who, in their words, could solve the problem only if they visualized the object clearly. For example, one of the subjects (M.L.) experienced difficulty in the beginning while solving the problem, since she represented a colored plastic cube which, after "sawing", appeared to be hollow. Only after she "replaced" it by an imaginary solid wooden cube could she solve the problem.

A second type of FOKN was shown by those subjects who solved the problem only in a logical way, without ever visualizing the object. The request of imagining the cube and solving the problem in the plane of representation led to resistance on their part.

The described relation between the type of FOKN change and the method of solving mental problems received strong confirmation in one exceptional case represented by subject A.K. /55

A.K. was a student in one of the Moscow colleges. After /56 lengthy training, he developed a phenomenal ability to visualize various data and to remember them in this way. In the beginning, he learned to represent graphically each individual element, and then "enlarged" the elements, seeking — for example — to see a whole line at the same time. By this method, A.K. increased the volume of the simultaneously "seen" material. Starting with individual letters and figures, he got to remember a whole page by visualizing it. If A.K. was presented with figures by means of which he was to perform arithmetical operations, then again he at first attempted to clearly "see" the presented data. In the subject's words, he always "saw" white figures against a black background.

We performed several series of experiments with subject A.K. One of them was the solution of mental problems with simultaneous recording of the FOKN. As indicated above, he performed the routine /58 arithmetical operations in the mind by visualing each figure. When requested to perform the operations by the usual method, he either got the wrong answer or refused to solve the problem. In the visual and auditory problem, the FOKN was not different in the case of A.K. from the FOKN in the other subjects; however, in the solving of the arithmetic problem, a visual FOKN was obtained in this subject (let us recall that in all the other subjects, a mental FOKN was obtained in the arithmetic problem). A similar result was obtained in A.K. when he solved the problem of sawing the imaginary cube. A.K. noted that in solving this problem, he had a clear visual image of the colored cube. The corresponding FOKN recordings and its mean cycles are presented in Figure 9A.

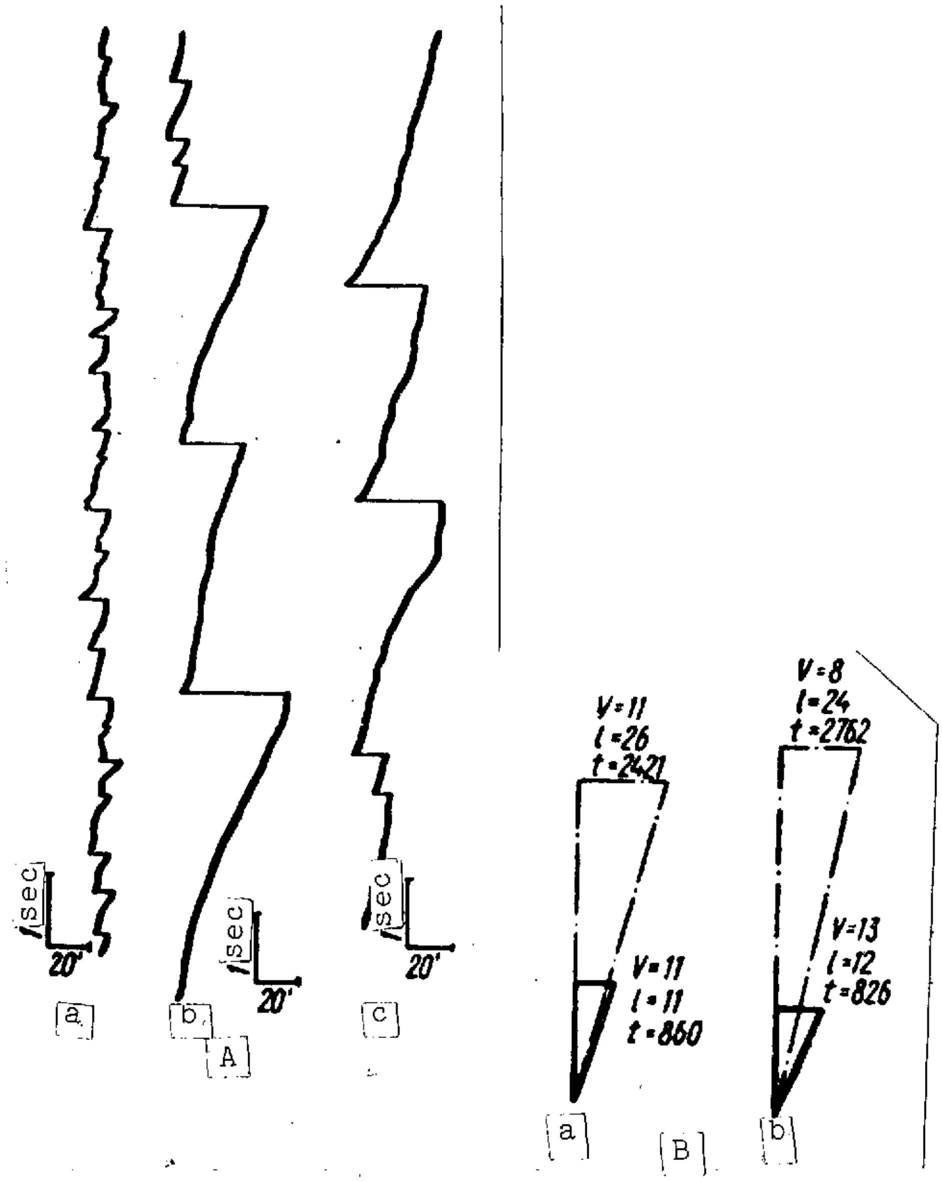

Figure 9. FOKN during solution of various mental problems by subject A.K.:

A — FOKN recordings: a — background FOKN; b — visual FOKN during solution of arithmetic exercises; the two black marks on the recordings indicate the end of the problem solving; c — visual FOKN during solving of the problem "small cube"; B — mean FOKN cycles: a — during solving of the arithmetic exercise; b — during solving of the "small cube" problem. The black lines in all the graphs indicate the background FOKN; the interrupted lines indicate the visual FOKN

6. In the series with discrimination of the noise squares in the plane of representation (fourth series), the subjects sometimes said "it seems to work", and sometimes "they saw nothing". Recording of the eye movements reveals only tracking movements, which

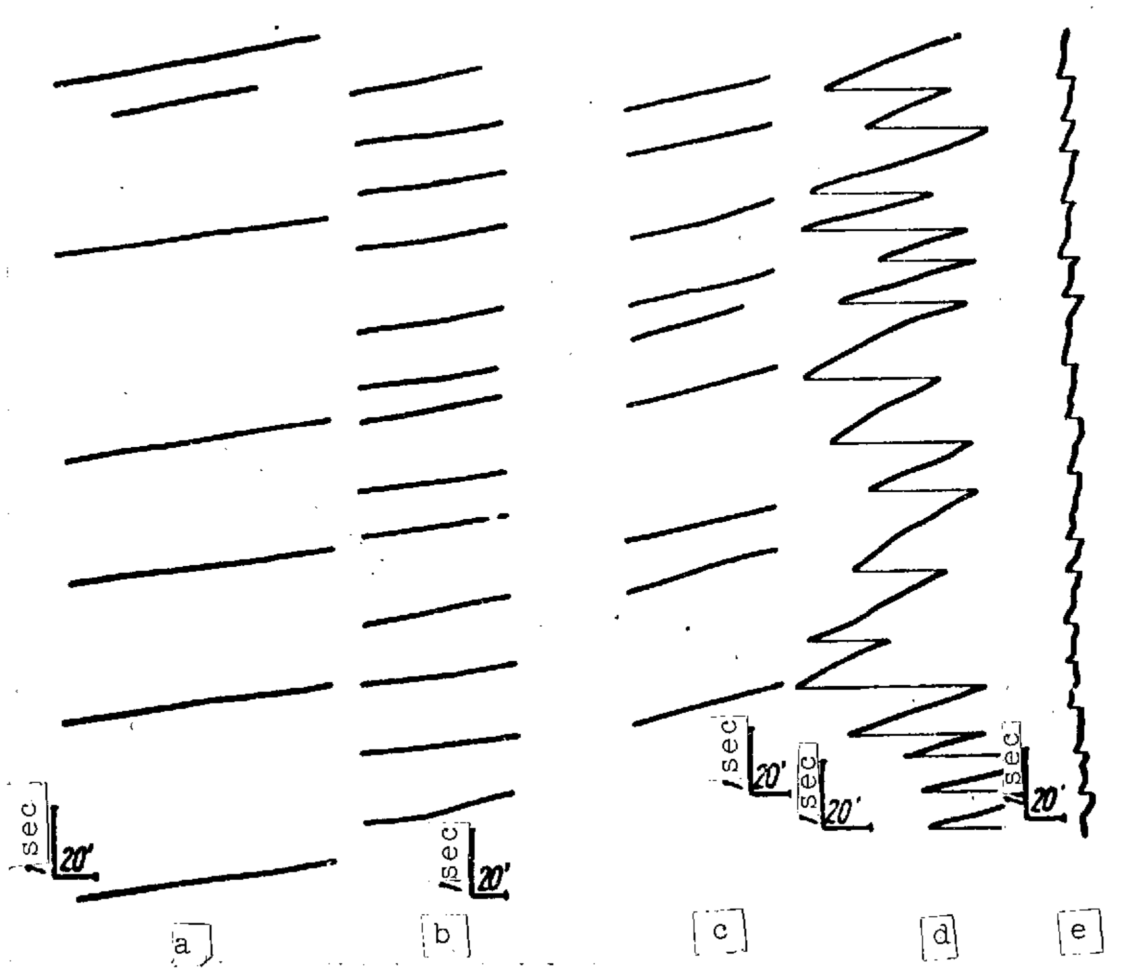

Figure 10. FOKN recordings during the attempt to visualize noise squares:

a — unsuccessful attempt by subject L.P.; b — the same, subject B.A.; c — the same, subject A.K.; d — weak visualization, subject A.K.; e — subject A.K. sees clearly the center of the noise square. Only the slow stages of the FOKN are seen in a, b, c. The rapid stages were not recorded because the beam went beyond the limits of the recording instrument

represented essentially the slow phases of the optokinetic nystagmus (OKN; Figure 10).

This series was performed with subject A.K. A few attempts ended in failure: the subject said that he could see the squares clearly only with closed eyes; when he opened his eyes, the moving background immediately knocked down the visualized image. In such unsuccessful attempts, the FOKN recording gave in this subject the same picture as in the other subjects (Figure 10c). A.K. wanted /59

very much to continue the training, in order to see the squares against the background of the stripes (as soon as the stripes were removed, the noise square reappeared). We organized such a training. In its course, the experimenter decreased gradually the brightness of the squares, from very bright to invisible, while the subject attempted to "retain" them. Soon, A.K. started to "see something" also against the background of the stripes, after removal of the squares. The FOKN recording at this stage revealed a markedly "unwinding" FOKN (Figure 10d). And suddenly, A.K. exclaimed that he saw a very bright center square. The obtained FOKN was similar to /60
the one during the fixation of a stationary dot (Figure 10e). Finally, the subject appeared to be able to visualize clearly all of the noise square; the moving background ceased to disturb him. He could not only see, but also work with these squares, by adjusting to the largest or smallest square. Figure 11a shows the FOKN recordings in A.K. during discrimination of the center square (50') in the visualized image; Figure 11c — during perception of the whole object (4°); Figure 11b — during discrimination of the noise square which was third from the edge and had a dimension of 3.7°. As seen from the recordings, a regular increase in the amplitude of the FOKN cycles was observed with the increase of the discriminated area (the same as in discriminating the corresponding visually presented squares).

7. In one experiment with colored squares, an even stranger /61
finding was obtained. In this experiment, contrary to the rule of presenting in the course of one recording a square with only one area, the subject was given in the beginning a 50' red square, and immediately afterwards — a 4° red square. The subject showed restlessness, and he reported that he could not adjust to the large square, since his attention was diverted by a bright green small square in the center of the large one (clearly, this was the negative afterimage of the previous small square). The FOKN in this half of the experiment showed characteristic features for perception of the small square (Figure 12A, a). The same result was obtained in another subject during percepting of the afterimage of the 4° square and of the afterimage of the 4° square against the background of the

8° square (see recordings and mean cycles in Figure 12).

Before proceeding to the discussion of the above-presented results, a few words should be said about the method of their processing and representation. First of all, as seen throughout the experiments, the main data with which we operated were the mean values of the duration, amplitude, and speed of the slow stages in the FOKN (correspondingly, t, l, and V). The mean cycles of the FOKN were constructed on the basis of these values. Obviously, from the enumerated three parameters, only two are independent or essential variables; the third results from the first two. Therefore, in presenting the results, it was sufficient to report on the direction and magnitude of the changes by either only t and l, or t and V, or l and V. Why did we not proceed in this way? The reason is that at this moment in time, we cannot say with any conviction

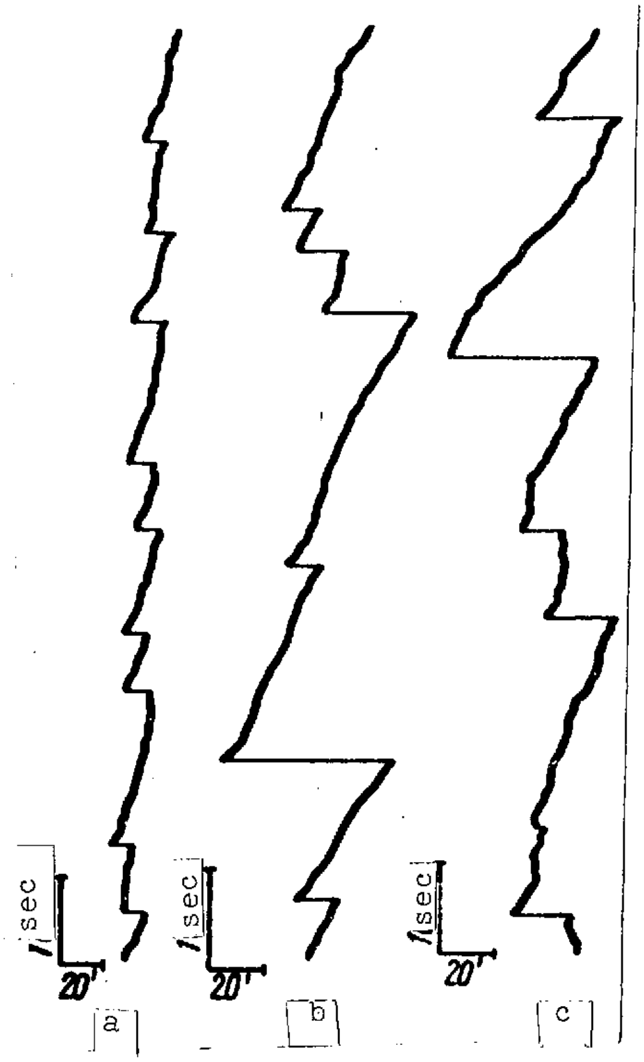

Figure 11. FOKN recordings during visualization of noise squares of different areas (subject A.K.): /62

a — 50' square (first in center; b — 4° square (third from the center; c — 5° square (all the figure)

which of the FOKN parameters are essential and related to the factors /63 which interest us, and which are derivatives. Moreover, it seems to us that the essential parameters may be different in different cases. Answering this question is a special problem in each case. We shall take this into account in examining the results of each series.

Second, the main method of the primary analysis of the results was two-by-two comparison of the mean values of the FOKN parameters within one problem while varying any one condition and keeping the others constant (for example, the randon and nonrandom reversal of the dube; discrimination of the noise and non-noise figures, logical solution of the problems and solution in the visual plane, etc.). Of course, it is desirable to perform wider comparisons between different problems — for example, the reversal of the cube and the discrimination of noise squares, or observation of the sensory figure and adjustment of the attention to a certain area, etc. However, we cannot do this, at least not yet, because each problem represents a particular combination of a whole series of essential factors (possibly still unknown to us); we do not dispose of the required scale for evaluating and ordering these factors. Nevertheless, we have tried to perform such comparisons wherever possible.

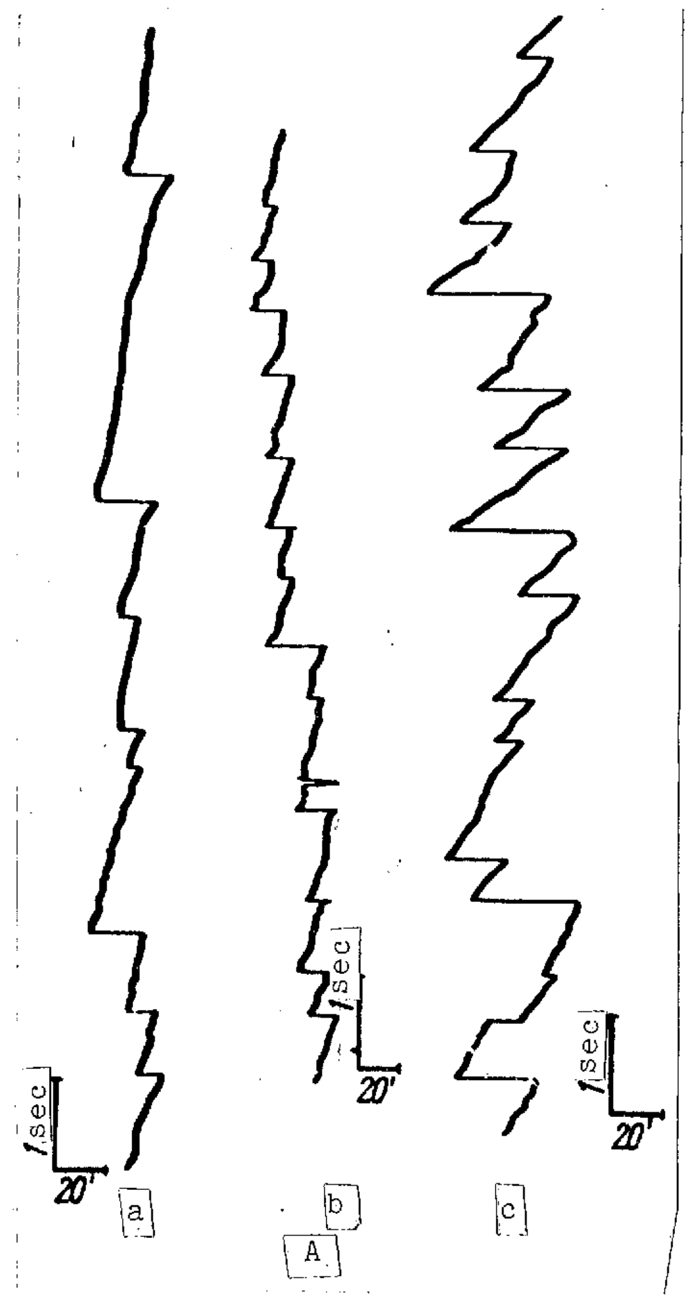

Figure 12. FOKN during the problem of adjusting the attention to squares of various areas and in the presence of the afterimage:

A — FOKN recordings: a — perception of the 4° squares in the presence of an afterimage of the 50'

(Figure and caption continued on following page)

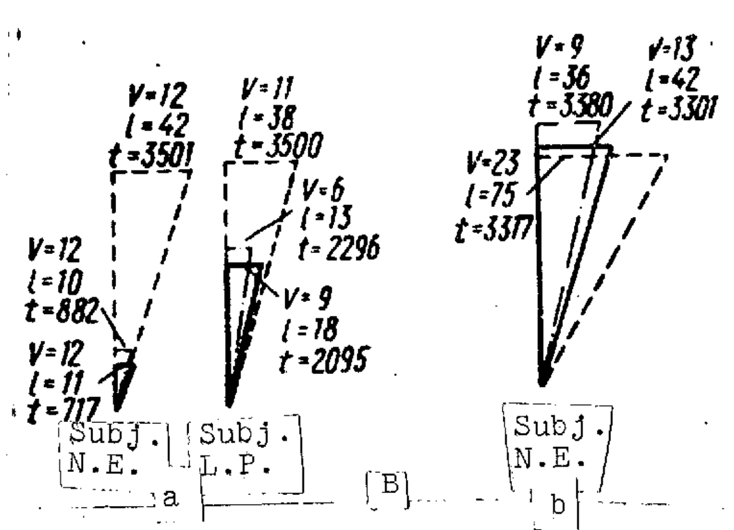

Figure 12. (continued):

squares (subject L.P.); b — the same, subject N.E.; c — perception of the 8° square in the presence of the afterimage of the 4° square (subject N.E.); B — Mean FOKN cycles: a — perception of the 4° square in the presence of the afterimage of the 50' square in two different subjects; b — perception of the 8° square in the presence of the afterimage of the 4° square. Continuous line — perception of the 4° square; interrupted line — perception of the 8° square in the presence of the afterimage of the 4° square; dotted line — perception of the 8° square without afterimage

Let us now sum up the main results of the presented results. First of all, as mentioned above, the obvious result of the entire series is the marked "visual" nature of the FOKN. Its typical signs are a strong increase in t, and, as a rule, a decrease in V. This creates an overall picture of a suppressed or "protracted" FOKN.

A no less clear result is the regular intensification of this visual character of FOKN with the increased complexity and randomness of the visual processes. Characteristic is the increase in the duration of the cycles t, which was considerable in some cases. Clear examples are the problems of the cube reversal (Figure 2), discrimination of the disguised figure of Gottschaldt (Figure 3), and discrimination of the noise square (Figure 6). The result obtained in the experiments with Shumann's board seemed to contradict this pattern: the t of the mean FOKN cycles was less decreased here in the discrimination of the nonsensory figure by comparison with the less difficult problem of perception of the sensory figure. However, we can explain this paradoxical result. First, most of our problems were solved by the subjects with a mininal number of adjusting jumps, i.e., under conditions of free, lasting eye fixation (we chose these conditions deliberately). The nonrandom jumps of the FOKN divided up this lasting fixation into the slow phases of the FOKN. However, sometimes — especially when the problem was more complicated — the subjects resorted to motor tactics. Just as in the case of distinguishing the above-indicated nonsensory figure, this tactic was typical for all the subjects. In this case, the fixation drifts were interrupted, not by reversible FOKN jumps, but instead by adjusting eye movements. As a result, they ceased to characterize the duration of the slow FOKN phases. This element has not been accounted for in the processing of the results, but instead, the durations of all the drifts were averaged, regardless of the nature of their "limiting" jumps. /64

Second, the subjects could not always cope with the presented problems. Some of them were excessively difficult, and were solved either partially or not at all. The discrimination of the nonsensory figure on Shumann's board was one of these problems: the subjects tried hard to see the cross, but they usually failed. As it happens in such cases, they passed to motor tactics, attempting, so to speak, to overcome the difficulty "by hook or by crook". It should be said that these tactics did not help either. The best result it could give was to enable the subject, by centering his gaze, to distinguish groups of small angular squares; in this case, the given cross appeared as the background of these figures (this was the procedure followed by one of the most assiduous of our subjects, S.I.). Subsequently, however, the relations of figure and ground still had to be changed, which in the case of the nonsensory figure proved to be an even more complicated problem than the initial discrimination of the cross. Thus, the only "pure" characteristic of the mean FOKN cycles relating to the discrimination of the nonsensory figure was the speed of the drift (V) which, as in the case of other complicated visual problems, was diminished here. The decrease of t reflects the subject's reaction to the inefficient performance of the task, and the search for solving the problem; l appears here as a simple consequence of V and t. The results of the experiments with the noise squares confirmed this. Although the discrimination of the noise squares by the subjects also took place with a variable degree of success, this problem was easier for them, since the period of success were longer and clearer. This made it possible to differentiate in the recordings parts relating to periods of success and failure in following the instructions. In the failure of solving the problem (Figure 7, continuous line), the mean cycles were remarkably similar to the mean cycles in the case of failure to discriminate the nonsensory figure on Shumann's chessboard.

The following uncontested result concerns the problem of adjusting the attention to squares of different areas. Worth mentioning /65 here is the regular increase in l together with the increase of the area of adjustment; V has the same tendency, while parameter t is apparently determined here by the values of l and V. The increase in the parameter l together with the increase in the area of the square can possibly be explained by means of an extension of the term "zones of insensitivity of the retina". This concept was introduced in order to pinpoint the central zone of the fovea within the limits of which a shift in the projection of a fixated dot does not cause any correcting jump (Glezer, 1959). In our case, the object of fixation was not a dot, but rather squares of increasing areas. It is natural to assume that in the problem of adjusting the attention to the area of the square, analogous insensitivity zones appear, but with a larger side than the square. The larger the square, the larger the zone and, consequently, the larger the permitted shift. The parallel increase in V can be explained by a weakening of the fixation. It is easier to concentrate attention on small objects; the opposite problem, i.e., dividing the attention over a large area, can cause a weakening of the fixation effort. This is probably what happened in our subjects, as a result of which the eye was subjected to the effect of the moving background to a larger extent, i.e., with a larger speed.

It seems to us that the results of the problems of object visualization are of great value. The findings of the typical visual character assumed by FOKN in periods of clear visualization confirm again the extraordinary sensitivity of this type of movement to the functional state of the visual system. On the other hand, it reveals a rare possibility for the objective demonstration of such deep forms of psychic activity as visual representation.

Finally, the last result which we would like to mention consists in the fact that a combination of different factors which affect the FOKN give a combined picture of its changes (Figure 6).

If we were to generalize all the above-presented results, it can be said that by its dynamics, FOKN throws light on a series of highly important properties and forms of visual activity.

At the present time, almost all investigators regard perception as an active process. Many authors emphasize the essential role of motor phasic reactions of the organism (Hebb, 1949; Leont'yev, 1959; Zaporozhets, Venger, Zinchenko, Ruzskaya, 1967; D. Bem, 1967, and others). The founder of this point of view on the perceptive processes was I. M. Sechenov, whose ideas have received great development in the views of Soviet psychologists. /66

Experimental psychology has accumulated numerous and very convincing evidence on the role of motor activity (movements of the eyes, head, hand, and body), for example, in the reconstruction of an optically transformed world (Stratton, 1896; Ewert, 1930; Kohler, 1962; K. Smith, W. Smith, 1962; Held, Hein, 1963, and others), and in normal perception after prolonged perceptive isolation (Bexton, Heron, Scott, 1954; Leidermann, 1958; Smith, Lewty, 1959, and others), etc.

However, there are also forms of perceptive activity which are supported by not only motor phase activity but, on the contrary, are accompanied by its suppression. A multitude of examples can be found in the literature, according to which a rich, intensive, internal activity hides behind the external immobility (Rubinshteyn, 1946). The clearest examples are the moments of listening, gazing, thinking, etc. It was noted long ago that tonic muscular activity is involved in the act of attention reversal (Ribot, 1892; Lange, 1893; James, 1902; Freeman, 1940, 1948a, 1948b; Dashiell, 1940; Paschal, 1941, and others). A whole series of perception theories places the emphasis on the role of tonic activity in perceptive processes [the senso-tonic theory of G. Verner and S. Vapner (1952), the theory of motor adjustment of F. Allport (1955), and others]. However, until now, tonic events in the organism have been insufficiently studied since, as noted by F. Allport (1955), some of these effects are elusive and require special refined methods of investigation. Our studies make us think that FOKN is one of these subtle indicators of the state of the eye's tonic system (Matyushkin, 1972). This indicator is correlated with many aspects of visual and sometimes intense internal work. Therefore, we consider it as the most adequate method for investigating internal forms of visual activity.

The physiological side of the described findings is still the least clear for us. It is quite evident that it requires special investigations. We have already noted that the form and features of FOKN can be related with the work of the subcortical nystagmogenic center and with the occipital and frontal cortical oculo-motor centers (Gippenreyter and Romanov, 1970). The results of the present work lead to a realization of the effect of the visual subcortical and cortical centers proper on the tonic system of the eyes.

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